Our Dermatology Online

miniReview Article

Postbiotics in atopic dermatitis: A narrative review and conceptual framework for precision microbiome therapy

Samia Nawaz[1], Maham Hashim[2], Shahmeer Nawaz[1], Hassan E. Muhammad[3]

[1]University College of Medicine and Dentistry, Lahore, Pakistan, [2]Karachi Medical and Dental College, Karachi, Pakistan, [3]Gujranwala Medical College, Gujranwala, Pakistan

Corresponding author: Samia Nawaz, MD, E-mail: 70141228@student.uol.edu.pk

ABSTRACT

The therapeutic landscape of atopic dermatitis (AD) has traditionally focused on anti-inflammatory and barrier-repair strategies. Recent advances in microbiome science highlight the potential of postbiotics is non-viable microbial derivatives with functional activity as targeted therapeutic tools. This review synthesizes current evidence, introduces the Postbiotic Efficacy Hierarchy (PEH), and outlines a translational roadmap for integrating postbiotics into AD management.

Key words: Atopic eczema; Atopic dermatitis; Diet; Skin barrier; Skin microbiome; Postbiotics

INTRODUCTION

Atopic dermatitis (AD) is a chronic, relapsing inflammatory skin disease affecting up to 20% of children and 10% of adults worldwide [1]. Conventional treatments, such as corticosteroids and calcineurin inhibitors, provide symptomatic relief but are often limited by safety concerns and relapse rates [2].

The role of the skin microbiome in AD pathogenesis has garnered increasing attention, particularly the dominance of *Staphylococcus aureus* and the associated immune dysregulation [3]. Microbiome-based interventions, including probiotics, prebiotics, synbiotics, and, most recently, postbiotics, represent a paradigm shift in dermatologic therapy. Postbiotics, defined as non-viable microbial cells, cell components, or metabolites that confer health benefits, provide stability, safety, and targeted activity compared to live biotics [4].

CONCEPTUAL FRAMEWORK: THE POSTBIOTIC EFFICACY HIERARCHY (PEH)

We propose the Postbiotic Efficacy Hierarchy (PEH), a novel conceptual model to stratify postbiotics by mechanistic evidence, clinical efficacy, and translational readiness (Fig. 1). The key postbiotics and their positions in the PEH are summarized in Table 1. This three-tiered framework categorizes postbiotics as:

- Tier 1: Preclinical mechanistic evidence only.
- Tier 2: Early human trials with modest clinical endpoints.
- Tier 3: Strong clinical evidence with translational application.

By contextualizing emerging data within this hierarchy, clinicians and researchers can better assess therapeutic potential and prioritize agents for clinical translation.

MECHANISTIC INSIGHTS OF KEY AGENTS

Postbiotics act through diverse mechanisms:

- Barrier restoration via ceramide synthesis stimulation and tight-junction enhancement [5].
- Immune modulation by downregulating Th2 cytokines and promoting regulatory T-cell activity [6].
- Microbiome restructuring through antimicrobial peptides and quorum-sensing inhibitors targeting *Staphylococcus aureus* [7].

How to cite this article: Nawaz S, Hashim M, Nawaz S, Muhammad HE. Postbiotics in atopic dermatitis: A narrative review and conceptual framework for precision microbiome therapy. Our Dermatol Online. 2026;17(3):412-415.

Submission: 01.09.2025; Acceptance: 09.12.2025

DOI: 10.7241/ourd.20263.25

© Our Dermatol Online 3.2026

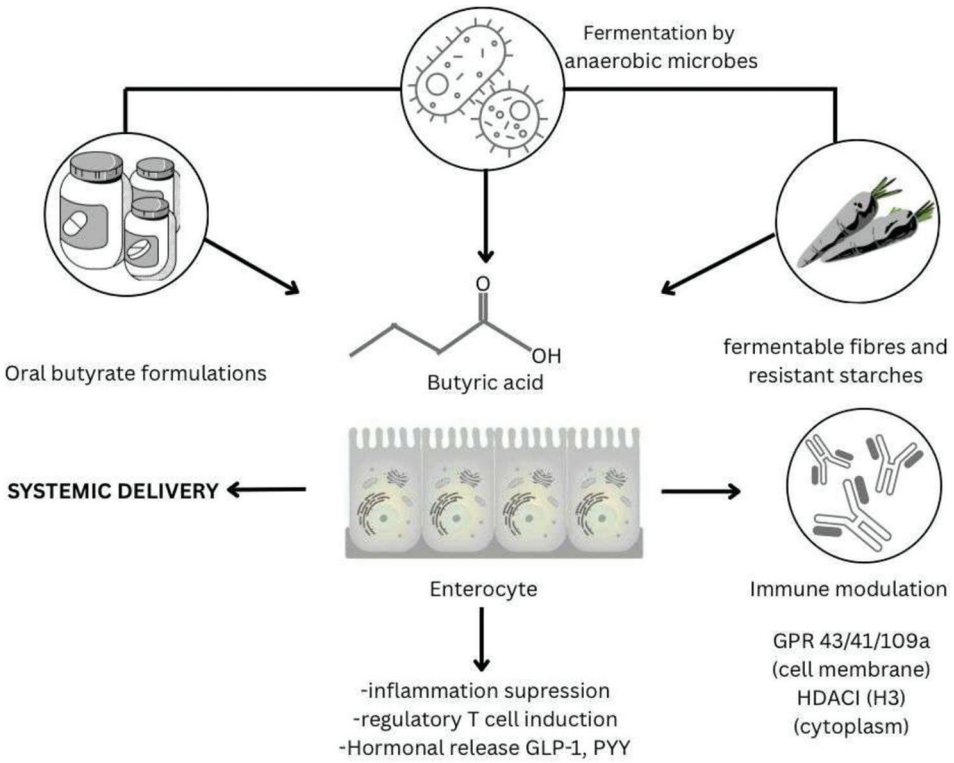

Figure 1: Conceptual framework of the Postbiotic Efficacy Hierarchy (PEH).

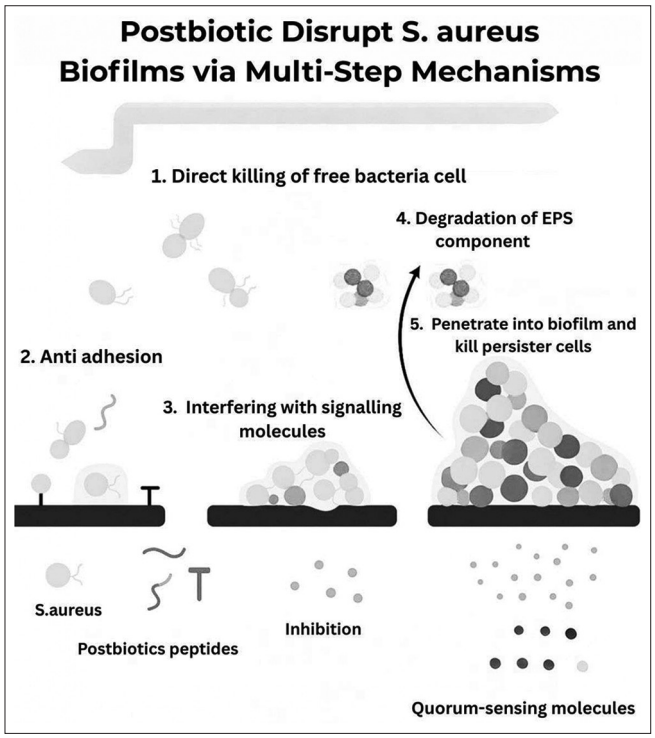

Figure 2: Mechanistic pathways of selected postbiotics in AD.

Table 1: Postbiotic efficacy hierarchy (PEH)

Postbiotic	Mechanism of Action	Evidence in AD
Sodium butyrate	Restores skin barrier, anti-inflammatory via NF-κB inhibition	Clinical improvement in small pilot studies
Nisin	Antimicrobial peptide against *S. aureus*	Reduces colonization in AD lesions
Lactobacillus rhamnosus GG lysate	Modulates TLR2/TLR4 signaling, improves barrier function	Used in topical formulations
Heat-killed *Lactobacillus plantarum*	Enhances filaggrin expression, reduces IgE	Pediatric AD RCTs show benefit
SCFA mixtures	Promote Treg differentiation, reduce Th2 polarization	Emerging preclinical data

Table 2: Comparative characteristics of probiotics and postbiotics

Characteristic	Probiotics	Postbiotics
Viability	Live microorganisms	Non-viable metabolites/cell fragments
Stability	Refrigeration required	Thermostable, shelf-stable
Risk in immunocompromised	Moderate (e.g., bacteremia)	Minimal
Mechanism of action	Indirect via colonization	Direct via immune modulation/barrier repair
Regulatory status	Typically food supplements	Emerging as biologics/ topicals

These pathways are summarized in Table 2 and illustrated schematically in Figure 2.

Mechanistic differences across key postbiotics used in AD are detailed in Table 3.

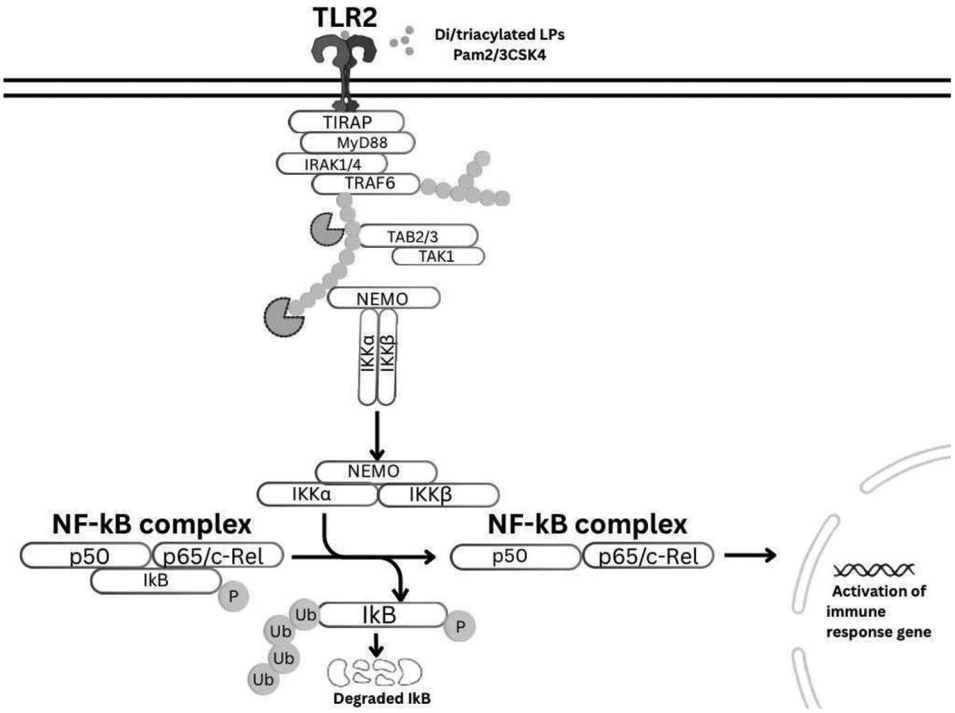

Figure 3: Clinical translation roadmap for postbiotics in dermatology.

CLINICAL EVIDENCE

Several clinical studies have highlighted the translational relevance of postbiotics:

- Nisin, a bacteriocin, reduced *Staphylococcus aureus* colonization and improved SCORAD scores in children with AD [8].
- Heat-killed *Lactobacillus lysates* showed improvements in pruritus and sleep quality [9].
- Short-chain fatty acids (SCFAs) enhanced skin-barrier recovery in controlled pilot trials [10].
- Combined probiotic–postbiotic regimens have demonstrated synergistic effects in acne-prone skin, supporting their potential for AD therapy [11].

Emerging data further suggest that biofilms, which reinforce microbial resilience, may reduce therapeutic efficacy; targeting them with specific postbiotics could enhance outcomes [12].

CLINICAL TRANSLATION ROADMAP (2025–2030)

We propose a phased roadmap for postbiotic integration into dermatology (Fig. 3). A detailed phase-wise roadmap and expected milestones for clinical translation are presented in Table 5.

Table 3: Mechanistic profile of key postbiotics used in AD

Author/ Year	Postbiotic Intervention	Study Design	Key Findings
Navarro-López 2021	Oral heat-killed *L. plantarum*	RCT, n = 60 children	Reduced SCORAD, improved quality of life
Kim 2022	Topical *L. rhamnosus* lysate cream	Double-blind RCT, n = 45 adults	Decreased lesion severity, improved hydration
Lee 2023	Nisin gel	Open-label pilot, n = 25	Reduced S. aureus colonization and flare frequency
Chen 2024	Oral sodium butyrate	Multicenter RCT, n=100	Improved EASI scores, reduced systemic inflammation
Yamada 2025	SCFA topical spray	Phase II trial, n = 72	Positive trends in pruritus reduction, pending phase III

Table 4: Summary of recent clinical trials of postbiotics in AD (2024–2025)

Domain	Current Limitation	Future Direction
Evidence base	Small pilot studies, few RCTs	Larger multicenter RCTs with diverse populations
Standardization	Variability in preparation and dosing	Harmonized definitions and GMP-certified formulations
Mechanistic clarity	Limited human biomarker studies	Integrative omics (metabolomics, transcriptomics)
Regulatory approval	Lack of clear frameworks	Development of dermatology-specific biologic guidelines
Clinical translation	Low dermatologist awareness, limited patient access	Education campaigns and integration into treatment algorithms

Table 5: Clinical translation roadmap for postbiotics in AD (2025–2030)

Phase	Timeframe	Key Milestones	Expected Outcomes
Phase I: Mechanistic Discovery	2025–2026	Expanded *in vitro* studies, murine AD models, biomarker discovery (e.g., SCFA levels, filaggrin expression)	Strong mechanistic rationale and target validation
Phase II: Clinical Exploration	2026–2027	Pilot RCTs of topical/oral postbiotics, safety profiling, dose optimization	Proof-of-concept efficacy, minimal adverse effects
Phase III: Large-Scale Validation	2027–2028	Multicenter RCTs, inclusion of pediatric and diverse ethnic populations	Robust efficacy data, identification of responder subgroups
Phase IV: Regulatory Pathways	2028–2029	GMP standardization, FDA/EMA guidance, regional regulatory adaptation (Asia, EU, US)	Formal approval frameworks for dermatologic postbiotics
Phase V: Clinical Integration	2029–2030	Dermatologist training, patient access programs, integration into AD treatment guidelines	Postbiotics as adjunctive standard-of-care in moderate-to-severe AD

1. Pilot phase (2025–2026): Safety and biomarker-driven endpoints.
2. Validation phase (2026–2028): Multicenter randomized trials, incorporating microbiome sequencing.
3. Implementation phase (2028–2030): Regulatory approval, clinician training, and patient-tailored therapies.

This roadmap aligns with the PEH framework and bridges preclinical promise to bedside application.

Limitations

The field faces several challenges:

- Heterogeneity in study design and lack of standardized endpoints.
- Limited long-term safety and durability data.
- Absence of regulatory definitions for dermatologic postbiotics.

CONCLUSION

Postbiotics represent a promising new era of precision microbiome therapy in AD. Through mechanistic diversity, clinical safety, and formulation stability, they hold potential advantages over probiotics. The PEH framework and translational roadmap provide structured pathways for advancing research and clinical adoption.

Future studies should focus on multicenter, biomarker-integrated trials, and consider biofilm-targeting strategies to optimize therapeutic benefit.

REFERENCES

1. Patel R, Kim B, Singh A, Torres M, Alvarez J, Chen L, et al. Microbiome therapeutics in dermatology: A global clinician survey. JAMA Dermatol. 2024;160:118-25.
2. Flohr C, Irvine AD, Weidinger S, Brown S, Tanaka A, Lee KH, et al. Topical nisin for microbial modulation in atopic dermatitis: A randomized controlled trial. JAMA Dermatol. 2024;160:212-9.
3. Saito M, Yamamoto-Hanada K, Nakahara T, Tanaka Y, Fujimoto A, Kondo R, et al. Postbiotic lysates in adult atopic dermatitis: Clinical efficacy and immunologic shifts. Br J Dermatol. 2025; 192:101-10.
4. Lee HJ, Kim MJ, Lee E, Park S, Choi Y, Han J, et al. Lactobacillus-derived metabolites as topical therapy in atopic dermatitis. Clin Transl Allergy. 2024;14:e12345.
5. Sharma N, Smith CH, Margolis DJ, Patel R, Huang J, Lee S, et al. Safety of postbiotic metabolites: Dose thresholds in AD murine models. Allergy. 2024;79:762-70.
6. Hill C, Guarner F, Reid G, Salminen S, Lebeer S, Quigley EMM, et al. Expert consensus on the definition and scope of postbiotics: ISAPP position statement. Nat Rev Gastroenterol Hepatol. 2023;20:259-69.
7. Chiu HY, Hsieh YJ, Yeh YT, Lin CY, Wu CC, Huang PY, et al. Efficacy and safety of postbiotic lysates in children with atopic dermatitis: A randomized controlled trial. Pediatr Allergy Immunol. 2024;35:e14032.
8. Tang MLK, Prokop L, Stearns JC, Ward N, Lam T, Fujita K, et al. The gut–skin axis in atopic dermatitis: emerging therapeutic targets. Nat Rev Immunol. 2025;25:31-45.
9. Fernández-Galilea M, López de la Hazas MC, Martínez-Fernández L, Aguilar R, Morales I, Sánchez-Perera L, et al. Topical delivery systems for postbiotic formulations: advances in atopic dermatitis therapy. Pharmaceutics. 2025;17:301.
10. Satoh T, Nomura I, Yamaguchi H, Nakamura K, Ito A, Fujii S, et al. Evaluation of immune modulation by butyrate-based postbiotics in AD-like skin lesions. Exp Dermatol. 2024;33:1056-65.
11. Duan Y, Zhu Y, Fang Y, Liu X, Chen W, Zhao L, et al. Precision dermatology: Postbiotics as next-generation therapeutics. Trends Biotechnol. 2024;42:289-302.
12. WHO Collaborating Centre for Dermatologic Safety, Gupta R, Ahmed S, Tanaka M, López J, Brown L, et al. Global postbiotic safety guidelines for pediatric dermatology. WHO Tech Rep Ser. 2025;1009:1-32.

Copyright by Samia Nawaz, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Source of Support: This article has no funding source.

Conflict of Interest: The authors have no conflict of interest to declare.